REDUCING EGG BREAKAGE IN MECHANIZED EGG-GRADING AND PACKING LINES

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PREFACE

This report is part of a broad research program designed to develop improved methods and equipment for the commercial handling of shell eggs. The phase of the research described in the report is directed toward pinpointing the areas in the grading and packing operations where shell eggs are being damaged in the central processing plants. The work was carried out by the Handling and Facilities Research Branch, Transportation and Facilities Research Division, in cooperation with the Department of Food Science and Technology, University of California, Davis. Appreciation is expressed to the management of the egg-grading and packing plants whose facilities were used during the studies.

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REDUCING EGG BREAKAGE IN MECHANIZED EGG-GRADING AND PACKING LINES

by

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SUMMARY

In typical egg-grading and packing plants in California, 2.32 to 11.76 percent of the eggs handled were either cracked or smashed while they were enroute from the nest (or cage) to the carton. Seventy-one percent of the breakage took place while the eggs were being transported between the nest and the packing plant, and 29 percent took place during the grading and packing operations--13 percent during the machine-loading and the washing and drying procedures, and 16 percent during the weighing and packing procedures.

So that the precise points where this damage occurred could be located, a tiny accelerometer (a device that converts mechanical energy to electrical energy) and a radio transmitter were designed and constructed so that they would fit into a plastic container approximately the size and shape of a normal hen egg. As the plastic test egg moved through the grading line, this device sensed any impact shock and transmitted a signal to a remote oscilloscope receiver at the moment the shock occurred.

The following procedures performed by the machines included in the tests were found to contribute to breakage:

1. Loading eggs onto the grading line conveyor.
2. Transferring eggs from the candling conveyor to the weighing station.
3. Dropping eggs into cartons at the packing station.

Assuming that method modification and redesign of the locations where damage occurs will reduce breakage by 50 percent, the saving to the U.S. poultry industry will be approximately $5 million per year.

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INTRODUCTION

The poultry industry in the United States produces approximately 5.8 billion dozen eggs annually 2/. A number of modern mechanized systems are used in grading and packing most of these eggs. In the process, a considerable number of eggs are cracked or smashed. Estimates based on industry claims indicate that an average breakage of 5 percent occurs in typical U.S. plants that use mechanized equipment. This figure includes a total loss of 28 million dozen smashed eggs and 260 million dozen cracked eggs that have been greatly reduced in value. Although an undetermined amount of this breakage is caused by careless handling and poor shell quality, it is theorized that much of the breakage is caused by machine handling. The objective of this study was to pinpoint the procedure(s) involving mechanized equipment that contribute to the damage that occurs during grading and packing.

PROCEDURE

The study was divided into two parts. During the first part, we determined the amount of breakage present in lots of eggs as they arrived at each plant, and then determined the breakage caused by machine handling in the grading and packing operations. For the second part of the study, conducted in the Food Science and Technology laboratory, University of California, Davis, a delicate shock-sensing device was developed. This device was used to pinpoint the exact location in the mechanized system where breakage takes place, and was then monitored during carefully controlled detection studies of the five selected mechanized systems used in the cooperating plants. These systems are typical of those commonly used in commercial grading and packing operations.

Determining Egg Breakage Levels Before and After Grading and Packing

To determine the shell damage in eggs awaiting grading and packing at the receiving cooler of the plant, we handcandled nine sample lots containing a total of approximately 10,000 eggs. These samples were provided by the five typical producer-packer plants 3/ that cooperated in the study. The checks that were detected were removed from each sample lot before the lot was loaded onto the grading line. After each lot passed through the line-loading, washing, and drying (to remove moisture that remained on the shell after washing) procedures, the checks that occurred during the procedures were removed and tallied at the in-line inspection (candling) booth. Then the lot continued through the weighing and packing procedures and was again inspected for checks.

2/ United States Department of Agriculture. Agricultural statistics 1970. 627 pp. Washington.

3/ Large-scale, on-the-farm egg grading and packing operations that handle the production from one or more large-scale producers.

Inspections during the study were made at points (fig. 1) where they would cause the least disturbance to operational procedures, and in such a way that the operations would remain typically commercial. The results showed that the breakage enroute from the nest (or cage) to the carton ranged from 2.32 to 11.76 percent (table 1). Seventy-one percent of the breakage was present before the eggs started through the egg-grading and packing line, 13 percent occurred during the loading, washing, and drying procedures, and 16 percent occurred during weighing and packing (fig. 2).

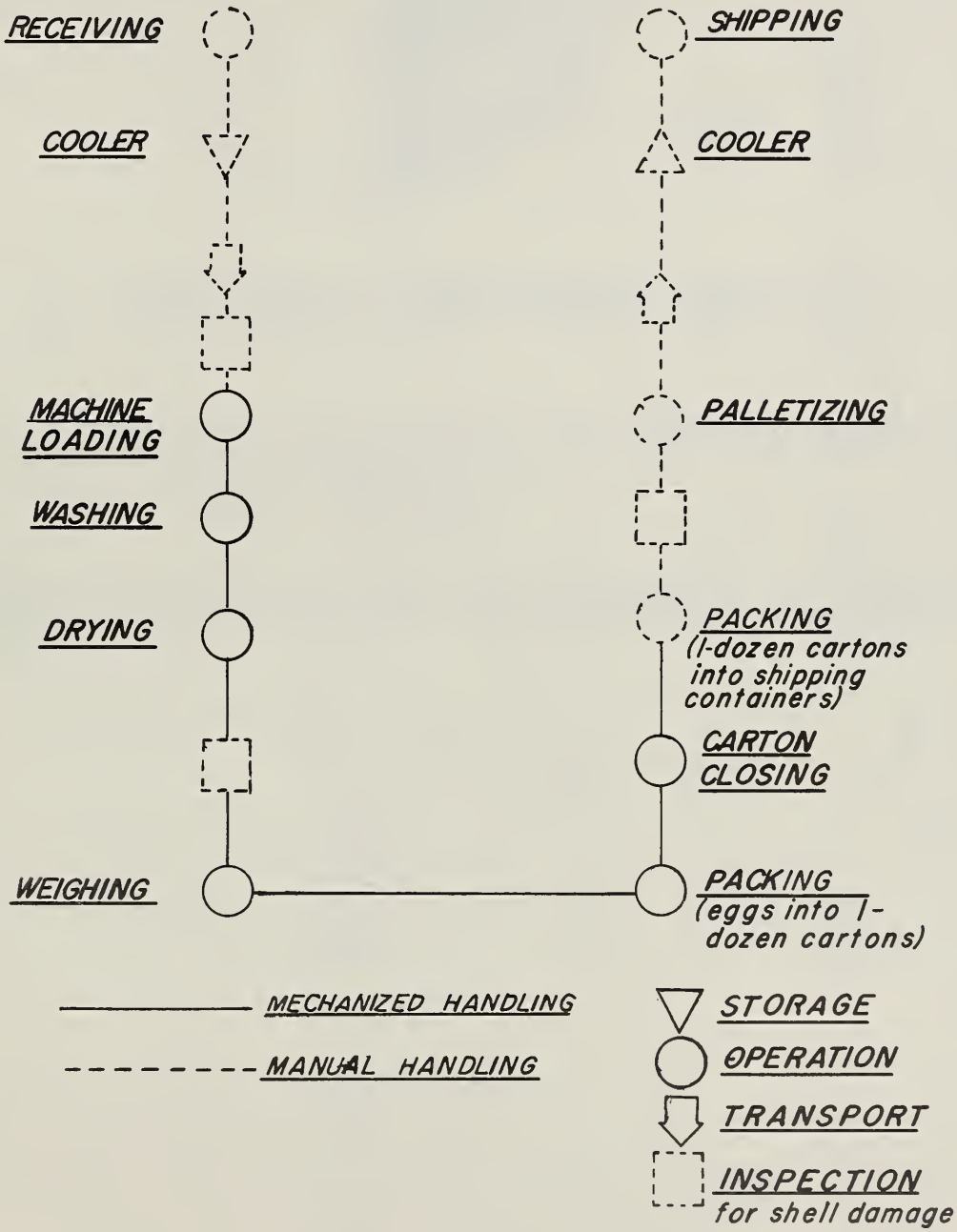

Figure 1.--Shell egg processing plant flow chart, showing inspection points for shell damage.

TABLE 1.--Shell damage before, during, and after machine handling in 5 egg-grading and packing plants

Plant and test number	Eggs per sample lot	Before machine handling 1/			During and after machine handling						Total checks removed before, during, and after machine handling
		Checks removed		Undamaged eggs	Checks removed at inspection station 2/		Checks removed after packing 3/		Total checks removed		
	No.	No.	Percent	No.	No.	Percent	No.	Percent	Percent		Percent
A:											
1	1,080	20	1.85	1,060	5	0.47	0	0	0.47		2.32
2	1,080	64	5.93	1,016	11	1.09	17	1.66	2.75		8.68
3	1,070	80	7.41	990	12	1.22	18	1.84	3.06		10.47
4	1,095	75	6.85	1,020	26	2.55	24	2.36	4.91		11.76
B:											
5	1,260	17	1.35	1,243	8	.64	7	.56	1.20		2.55
C:											
6	1,084	46	4.24	1,038	10	.97	17	1.64	2.61		6.85
7	1,146	66	5.76	1,080	11	1.02	4	.37	1.39		7.15
D:											
8	1,080	68	6.25	1,020	10	.98	5	.49	1.47		7.72
E:											
9	1,071	81	7.56	870	3	.34	16	1.84	2.18		9.74

1/ Samples drawn in receiving cooler from selected lots of eggs awaiting grading.
2/ After line loading, washing, and drying procedures.
3/ After sizing, packing, and placing cartons into shipping containers.

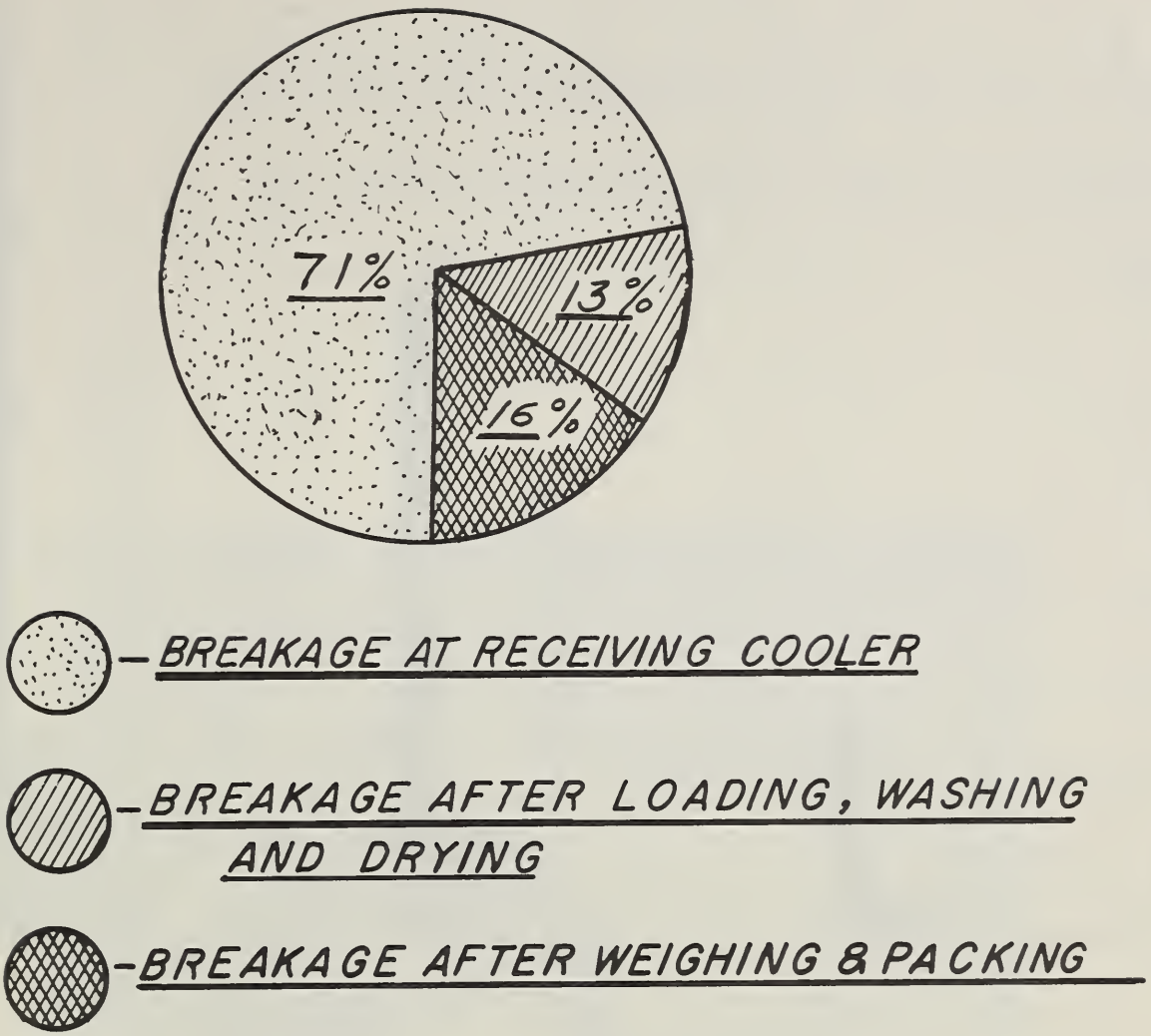

Figure 2.--Percentage of breakage (checks) before, during, and after weighing and packing.

Because factors such as bird age, strain, feed, disease, and management practices affect the quality of the shell, sample lots were classified as to shell quality (that is, shells produced by flocks having high, medium, and low incidence of breakage), based on records kept by management at the plants studied. As expected, inspection results showed that shell damage increases significantly as shell quality decreases (fig. 3).

Machine maintenance can affect the shell damage rate, and this rate can also be affected by a production speed equal to or in excess of the rated capacity of a particular machine. In the plants selected for this study, however, equipment was in good working order and was not being operated at the higher speeds.

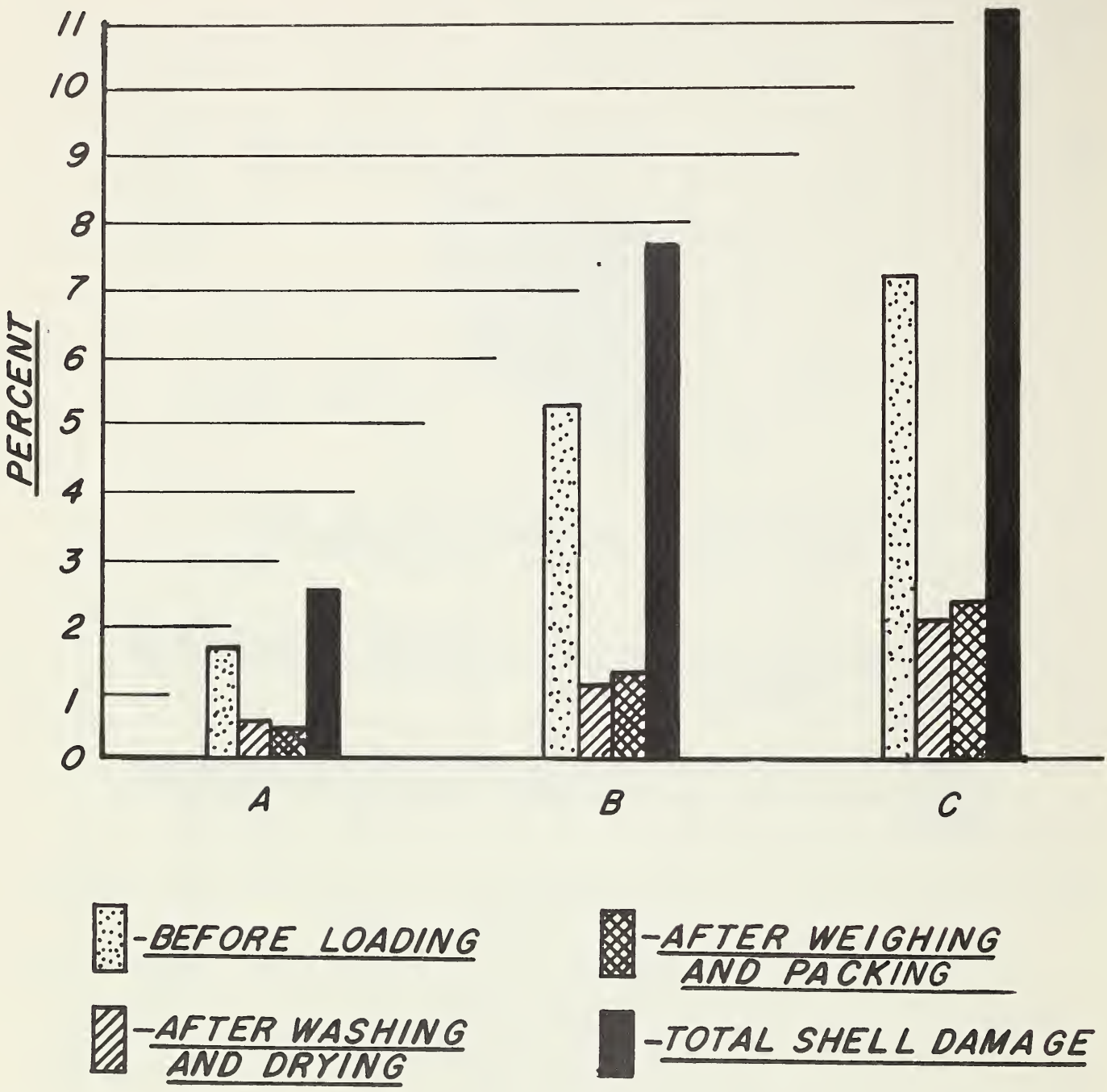

Figure 3.--Percentage of shell damage in sample egg lots separated by shell quality: A, Production from flocks having low incidence of breakage; B, production from flocks having average incidence of breakage; and C, production from flocks having high incidence of breakage.

Pinpointing Breakage in the Grading and Packing Operations

Assuming that eggs with sound shells would be graded by properly maintained and properly operated grading equipment, research was undertaken to find a way to pinpoint equipment design features or operating methods that might cause breakage. The result of this research was the sensitive electronic shock-sensing device mentioned in the "Procedure" section of this report. The

device consisted of a tiny accelerometer (an electrical apparatus that converts mechanical energy to electrical energy) and radio transmitter system built into a plastic, waterproof container that approximated the size and shape of a normal hen egg (fig. 4). When the plastic "egg" was sent through the grading line as a shock detector, any sudden impact encountered caused the accelerometer to generate a signal that was instantly transmitted by the radio transmitter to a remote oscilloscope receiver. The impacts showed up on the receiver screen as sharp spikes that could be measured as to severity. 4/

Figure 4.--Electronic "egg" beside a hen egg.

4/ Detailed specifications of the device were reported by W. L. Shupe and R. M. Lake in Designing an instrumented test egg for detecting impact breakage. The Shock and Vibration Bul. 41, Part 3, p. 11. 1970.

A threaded opening on the large end of the plastic test egg (fig. 5) allowed the insertion, fastening, adjusting, and maintenance of the electronic assembly. After all of the parts were inserted into the plastic container and the cap was screwed into place, the shock-sensing device was subjected to laboratory tests.

In these tests, a measurement was made of the maximum height from which a normal egg could be dropped onto a hard surface without cracking. The plastic egg was then dropped from the same height and onto a similar surface. The impact produced a signal spike on the receiver screen. This spike was measured, and its highest point was identified as the peak at or beyond which a normal egg would crack. When the test egg was run through a component of a mechanized grading system, the images of the impact signal spikes on the screen were identified, photographed, and measured.

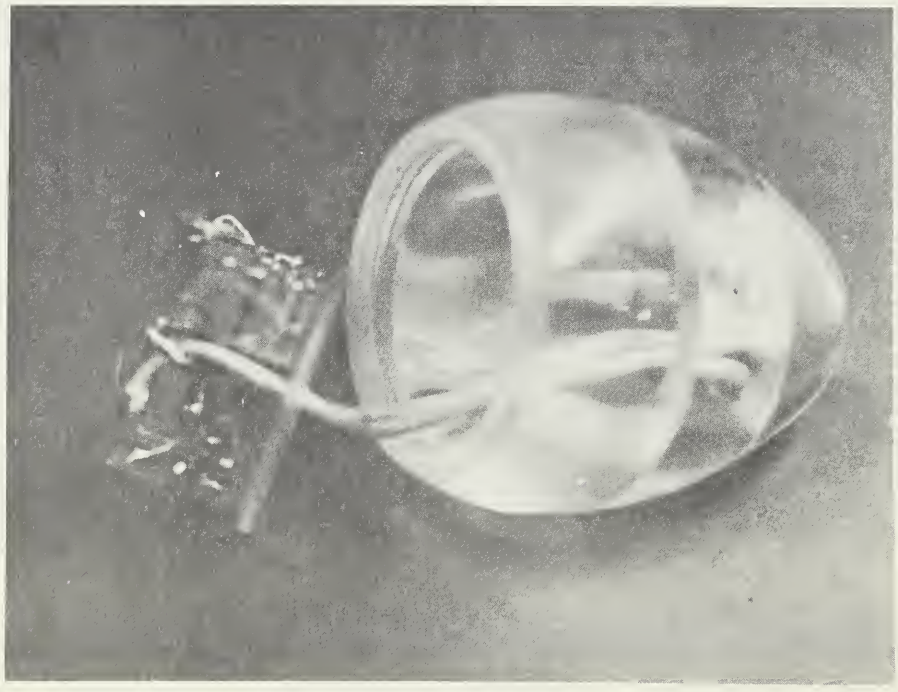

Figure 5.--Open plastic "egg" with threaded cap removed and accelerometer and transmitter exposed.

The test egg was then used in a commercial egg-processing line to pinpoint areas of high impact. These tests required minor modification of the electrical circuits within the egg and adjustments in the design and position of the receiving antenna. After a number of tests were made, we were able to

differentiate between significant shock peaks and spurious signals picked up from such sources as grading-line motors, relays, and switches.

RESULTS

The commercial egg-processing test results showed an occasional impact of sufficient severity to cause breakage at three locations in all of the mechanical systems tested. The procedures involved were: (1) Loading eggs onto the grading-line conveyor, (2) transferring eggs from the candling conveyor to the weighing stations, and (3) dropping eggs into cartons at the packing stations (fig. 6).

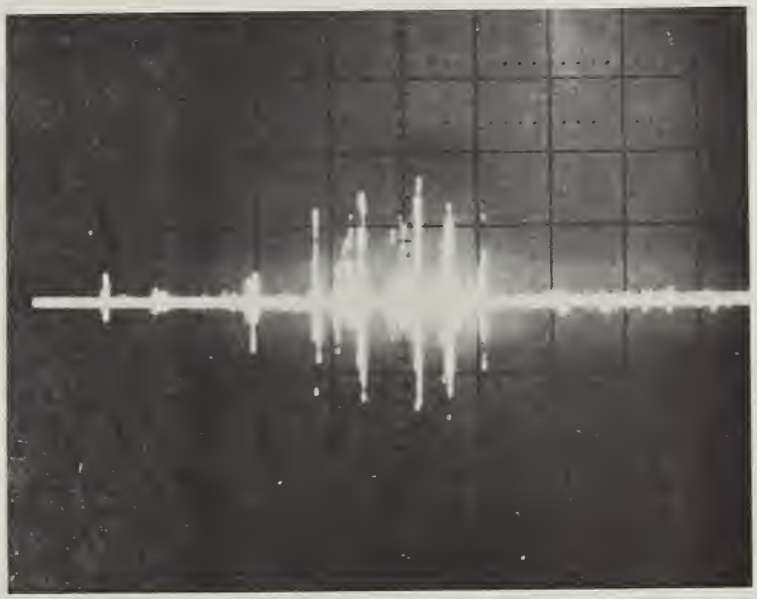

Figure 6.--Spikes record high impact from test egg during packing.

In one system tested, a fourth area of severe impact was detected in the area receiving eggs after weighing. Here, eggs that accumulated for packing rolled against other eggs or guide bars in the area, or both.

CONCLUSION AND RECOMMENDATIONS

Egg breakage in the commercial egg-grading and packing plants included in the study ranged from 2.32 to 11.76 percent. The highest incidence of shell damage occurred before the eggs were loaded onto the grading line. This damage represented 71 percent of the total number of damaged eggs. The remaining 29 percent were cracked in the mechanized line--13 percent during the loading, washing, and drying procedures, and 16 percent during weighing and packing.

Although evaluations of breakage--prevention methods are not within the scope of this study, we suggest that cage construction, egg gathering methods, equipment, and production management practices be evaluated to reduce the high incidence of breakage before the eggs are graded and packed.

The breakage (29 percent) in the grading lines studied can be reduced by modifying the loading equipment in the mechanized line. Breakage should be minimized if the impact force of the transfer device is lowered without reduction of positive vacuum pickup. At the intersection of the candling conveyor and weighing mechanism, the drop distance should be reduced and the weighing mechanism that receives the eggs from the candling conveyor should be equipped with cushioning material that is easily cleaned and moisture proof. The drop distance required to orient eggs (small end down) as they fall into the container should be reduced, or a guide mechanism should be designed that will eliminate the hazard of eggs colliding as they enter the container.

When the supply of graded eggs to be packed accumulates at rates greater than the packing heads can receive them, the line speed should be reduced and the temporary holding area should be cushioned properly.

Finally, the power sources and moving parts of the egg-handling machines should be serviced properly and operated slightly below their rated capacity.